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DATA FOR THE DETERMINATION OF HUMAN ENTOZOA

By HENRY B. WARD

WITH FOUR PLATES

The attention of the scientific world has been powerfully drawn to the endoparasites of man by recent discoveries demonstrating their great importance in the etiology of disease. Some notices regarding parasites from the human host have been found in the earliest records of disease. The occurrence of tapeworms and of the larger round worms is recorded not only in the first medical writings of the Greeks, but even in the earlier chronicles of the Hebrews and Egyptians; and in a few instances the records include accurate statements regarding the cause and remedy for the disease as well as the means of distinguishing different forms of such parasitic worms. These data cover, however, only the more conspicuous forms and are often confused by a mass of fables and superstitions, so as to weaken or destroy the value of the truth. With increased study of scientific subjects in general a larger number of such species came to be known. But even to-day they are not as a rule more than superficially known and it is only very recently that attention has been generally called to their number and the often serious effects which they produce in the human organism.

Thirty years ago Leuckart listed thirty species which had been found in man and, in company with Virchow and a long list of other investigators, called repeated attention to the deleterious effect certain species exert. Braun's more recent work (1902) discusses of certain and doubtful species fifteen Trematoda, twenty Cestoda and thirty-eight Nematoda, besides thirty to forty Protozoa, which have been recorded from the human host. In studies on the various groups which I have recently published this list is increased by two species although the interval between the publication of Braun's lists and my own is not a full year.

The various studies, however, have chiefly been made on forms found in the old world, and the well known species are in the main those of European countries. Within very recent times these studies have begun to be extended over other lands. All the new forms recorded during the last five years have been extra-European, either new species peculiar to other lands, or new regions within which known forms have been found to exist, so that one may say the greatest advance has been in knowledge of the geographical distribution of human parasites, although the life history of many species has also been strikingly elucidated. The previously recorded large number of isolated cases of the occurrence of certain species has been supplemented by other cases showing more general occurrence or wider distribution, the results of which have been to demonstrate that these parasites are far more common and widely distributed than was believed heretofore. The accompanying table which lists all human parasites of the various groups of worms heretofore recorded with a statement of the regions in which they are known to occur will be of value as indicating the present knowledge on the subject. It has seemed to me best to confine the list to the worms and to exclude the protozoan parasites for the double reason that the latter are very imperfectly known and it would be difficult to present a satisfactory list, and in the second place that they are also more difficult to determine, even by the professional microscopist, and present insuperable difficulties to the ordinary practitioner.

TABLE I.

Parasite and Organ Infested	Stage	Type of Parasitism	Geographical Distribution						Recorded Frequence as Human Parasite in Normal Habitat
			Europe	Asia	Africa	North America	South America	Australia	
Skin and Subdermal Tissue:									
Leptodera Niellyi	Larva	Accidental?	*						One
Gnathostome siamense	Adult	Occasional		*					One
Filaria medinensis	"	Normal	z	**	**	z	*		Abundant
Uncinaria duodenalis[1]	Larva	"	*	**	**	*	?		"
Eye:									
Cysticercus cellulosæ	Larva	Erratic	*						Rare
Echinococcus polymorphus	"	"	*			*			"
Filaria loa	Adult	Normal	z		**	z	z		Frequent
" lentis	Young	?	?	?	?				Uncertain
" conjunctivæ	Adult	Occasional	*						Rare

TABLE I.—*Continued.*

Parasite and Organ Infested	Stage	Type of Parasitism	Geographical Distribution						Recorded Frequence as Human Parasite in Normal Habitat
			Europe	Asia	Africa	North America	South America	Australia	
Brain and Membrane:									
Paragonimus Westermanii	Adult	Erratic	†	**		†			Rare
Cysticercus racemosus (= C. cellulosæ)	Larva	"	*			*			"
Cysticercus acanthotrias	"	"?	*			*			"
Echinococcus polymorphus	"	Erratic	*			*			"
Connective Tissue:									
Fasciola hepatica	Adult	"	**	†		†	†	†	"
Paragonimus Westermanii	"	"	†	**		†			"
Bothriocephalus Mansoni	Larva	Occasional		*					"
Cysticercus cellulosæ	"	Normal	**			*			Frequent
" tenuicollis	"	?				*			Once?
" acanthotrias	"	Normal	*			*			Rare
Echinococcus polymorphus	"	"	**			*		*	Frequent
Filaria perstans	Adult	"?	z		**		*?		Rare
" loa	"	"	z		**	z	z		Frequent
" Ozzardi	"	"?					*		Rare
Muscles:									
Cysticercus cellulosæ	Larva	"	**			*			Frequent
" acanthotrias	"	"	*			*			Rare
Trichinella spiralis	"	"	*	**	*	*		*	Abundant
Heart:									
Filaria Magalhæsi	Adult	?					*		Once
Cysticercus cellulosæ	Larva	Erratic	*						Rare
Echinococcus polymorphus	"	"	*			*			"
Blood Vessels:									
Fasciola hepatica	Adult	"	**	†		†	†	†	"
Schistosoma hæmatobium	"	Normal	z	z	**	z			Frequent
Echinoccus polymorphus	Larva	"	**			*		*	Rare
Filaria immitis	Adult	?	*?	†		†	†		Doubtful
" romanorum-orientalis	"	?	*						Once
" embryos[1] (see Table II)	Larva	Normal	*	*	*	*	*		
Lymph Vessels:									
Filaria Bancrofti[2]	Adult	"	*?	**	**	*	*?	*	Abundant
" volvulus	"	"	z	*?	**				Rarr
" lymphatica	"	Occasional	*						Twice
" equina	"	"	*						Twice
Lungs:									
Fasciola angusta	"	Erratic			†		z?		Once
Paragonimus Westermanii	"	Normal	†	**		†			Abundant
Cysticercus cellulosæ	Larva	"	*						Rare
Echinococcus polymorphus	Larva	Normal	*			*			"
Strongylus apri	Adult	Occasional	*						"
Liver:									
Fasciola hepatica	"	"	*	†		†	†	†	"
Paragonimus Westermanii	"	Erratic	†	**		†			Frequent
Opisthorchis felineus	"	Normal	*	*					"
" sinensis	"	"		**		z			"
" noverca	"	Occasional?		*					Once

TABLE I.—*Continued.*

Parasite and Organ Infested	Stage	Type of Parasitism	Geographical Distribution						Recorded Frequence as Human Parasite in Normal Habitat
			Europe	Asia	Africa	North America	South America	Australia	
Metorchis truncatus	Adult	Occasional		*					Once
Dicrocoelium lanceatum	"	"	*	†	*	†	†	†	Rare
Cysticercus cellulosae	Larva	Normal	*			†			"
Echinococcus polymorphus	"	"	**			*		*	Frequent
Small Intestines :									
Fasciolopsis Buski	Adult	"		**					Rare
Fasciolopsis Rathouisi	"	Occasional		*					Once
Opisthorchis felineus	"	Erratic	*	*					Rare
" sinensis	"	"		*		z			"
Heterophyes heterophyes	"	Normal		†	**				Frequent
Dibothriocephalus latus	"	"	**	**	*	z			Abundant
" cordatus	"	Occasional	*			*			Rare
Diplogonoporus grandis	"	"		**					"
Dipylidium caninum	"	"	*			*			"
Hymenolepis nama	"	Normal ?	*	*	*	*?	*		Frequent
" diminuta	"	Occasional	*			*	*		Rare
" lanceolata	"	"	*						Once
Davainea madagascariensis	"	Occasional ?		*	*		*		Rare
" asiatica	Adult	?		*					Once
Tænia solium	"	Normal	*	*	*	*			Abundant
" serrata	"	?			*				Twice ?
" saginata	"	Normal	*	*	*	*			Abundant
" africana	"	" ?			*				Once
" confusa	"	" ?				*			Twice
" hominis	"	?		*					Once
Strongyloides stercoralis	"	Normal	*	**	**	*	*		Abundant
Trichinella spiralis[2]	"	"	*	**	*	*		*	"
Strongylus subtilis	"	"		*	*				Twice
Uncinaria duodenalis	"	"	*	*	*	*	*?		Abundant
" americana	"	"		*		**	*?		"
Physaloptera caucasica	"	?		*					Once
Ascaris lumbricoides	"	Normal	*	*	*	*			Abundant
" canis	"	Occasional	*			*			Rare
" maritima	"	"				*			Once
Oxyuris vermicularis	"	Normal	*	*	*	*			Abundant
Gigantorhynchus gigas	"	Occasional	*?			†			Rare
" moniliformis	"	"	*						"
Echinorhynchus hominis	"	?	*						Once
Large Intestine :									
Gastrodiscus hominis	"	Occasional ?		*					Twice
Trichuris trichiura	"	Normal	*	*	*	*	*		Abundant
Oxyuris vermicularis	Female	"	*	*	*	*			"
Kidney :									
Echinococcus polymorphus	Larva	"	*			*			Rare
Dioctophyme renale	Adult	Occasional	*			†	†		"
Bladder :									
Leptodera pellio	"	Accidental	*						Once
Anguillula aceti	"	"				*			Twice
Filaria restiformis	"	?				*			Once

TABLE I.

EXPLANATION OF SIGNS.

** Recorded from man ; autochthonous to region.
* Recorded from man ; probably endemic, though often secondarily.
z Recorded from man ; probably acquired elsewhere.
† Recorded from some other host, hence possible in man. This entry is without reference to the particular organ under consideration.
? Record open to question.
1 Distribution of larva after that of adult form.
2 " " adult " " " larval "

It may be confessed at the outset that the table is probably incomplete. The individual records are much scattered, and in such form as to demand extensive critical editing. It would be improbable, then, that, even with the great care which has been exercised, all records should have been included. So far as the list concerns Europe and the United States, however, I think it may be said that it is most nearly complete and includes all but the most obscure records up to the present date. It should nevertheless be borne in mind that one may certainly expect further evidence of the presence of some of these species in unrecorded regions and of the existence of new species in most of the regions of the world. Additional strength is given to this general premise by the discoveries which have been made within the past decade in these United States. Thus Thayer has demonstrated the existence here of the Indo-European *Strongyloides stercoralis,* White has discovered the Asiatic *Opisthorchis sinensis,* I have found the Asiatic Lung fluke, *Paragonimus Westermanii* and a new human tapeworm, *Taenia confusa,* while Stiles has in addition to records on the vinegar eel, *Anguillula aceti,* and other forms new as human parasites here, contributed the most important of all these studies, namely that on the widespread occurrence of a new hook worm, *Uncinaria americana,* which is of great etiological significance over large areas of our country.

The history of helminthology shows a characteritic vibration from one extreme of belief to the other regarding the importance to be attached to these forms from the clinical standpoint. In the belief of the medical profession two hundred years ago there was no disease, real or imaginary, which was not due to the presence and effect of some kind of parasite. Each ailment had its particular "worm" in its characteristic location. This was a direct result of the endeavor to reduce every malady to some definite cause, and from a joining of the unknown sickness with the parasites of which they knew as little. Under the influence of study and of increase of knowledge regarding the parasites, such a theory was seen to be untenable, and the movement in the opposite direction began, a tendency which may be said by this time to have passed its height.

This opposite extreme has been manifested in our own land, since there has prevailed during recent years among the medical men of this country an exaggerated idea of the unimportance of human parasites. It has been very generally maintained that the country was less infested than the Old World, or that the forms, after all, were of little significance in the etiology of disease. I am of the opinion that the discoveries referred to furnish ample grounds for a modification of the position of indifference heretofore assumed, and in the treatment of disease call for more careful consideration of such forms as possible factors of etiological significance. The clinical importance of parasites is generally recognized in such cases as *Bothriocephalus* anemia, of which only a very few instances are on record in the United States, and for a few other species also, but similar significance has not been accorded to most forms.

It is true that internal parasites are very widely distributed and that scarcely any individual is entirely free from them. They are, however, usually present in limited numbers, and are believed to be harmless if infrequent or of small size. This does not seem to be strictly correct, for while it is doubtless true that the effect of a single parasite, or even of a considerable number of minute size, is small and difficult to measure or estimate, it is equally clear that even this is a certain drain on the host. Furthermore, the tax on the host is in proportion not only to the number and size but also to the habits of the parasites present. Thus there is a great difference whether the parasite is active and growing in the alimentary canal or some other cavity in the body of the host, or passively resting in the midst of the tissue of some organ.

While encysted parasites exercise a continued and sometimes serious pressure on adjacent tissue, yet the draft on the host by free parasites is much the greatest and manifests itself in three ways. The parasite requires a certain amount of food for its support; this it takes directly from the host, either from that which the latter has digested for its own use, if the parasite be in the alimentary canal, or from material which the host has formed to perfom certain work, as in the case of blood parasites, or from the tissue of the host, as some intestinal worms which feed on the cells composing the wall of the intestine. In any case the host expends at least the extra energy necessary to procure and digest the food taken by the parasite, and this extra labor will be directly in proportion to the amount of food taken, or in general to the size of the parasite and to its fertility.

In the second place the parasite occupies a certain amount of space and correspondingly reduces the calibre of the tube in which it lives. Unless a considerable number are present this is hardly a practical stoppage for the alimentary canal, although in several recorded cases death has followed occlusion of the canal by a mass of Ascarids, but in the case of the blood system a vessel may be closed or a clot formed by the presence of even a very few parasites.

In the third place, active parasites will, by their movements, give rise to a certain amount of irritation and inflammation of the membranes over which they move. This is in some ways, perhaps, the most serious trouble which a few parasites can cause, and it is much increased if in the special case the parasite obtains its food at the expense of the tissues of the host, that is, if it tears or consumes the walls of the cavity in which it lives. A secondary, though possible, result of this manner of living is the liability of rupturing some blood vessel, with consequent serious results as in the case of certain lung flukes which may chance upon some large blood vessel and in this way produce even fatal hemorrhage. In the alimentary canal a single *Ascaris* may perforate the wall and induce fatal peritonitis as has been observed several times in recent years. It is evident, then, that no more than a single active parasite may be dangerous, and that it is always some tax on the domestic economy of its host. Of course the effect of a microscopic worm in the alimentary canal of an elephant will be so small that it could hardly be calculated in any way; but this reasoning should not be extended too far. The disturbance produced in the human system by a single tape-worm is sufficient to call for prompt measures to remove it.

Recent studies, however, have demonstrated the presence of haemoglobin in the alimentary canal of many nematode parasites, the pathologic effect of whose activities must be counted much more important than heretofore estimated by reason of this blood sucking habit. Thus in severe cases of uncinariasis the amount of blood lost from myriads of minute hemorrhages imparts a characteristic reddish-brown color to the feces, and is so extensive that fecal matter will leave a distinct blood stain on blotting paper. At the same time the intestinal wall becomes seriously affected, and affords places of easy attack for any pathogenic germs which may be present. This indirect damage may be very serious in the individual instance and may include primarily or secondarily undesirable regressive or progressive histological changes, inflammatory processes, and disturbances in the circulation.

Another source of danger from parasites is one which has long been surmised but only recently demonstrated. A number of investigators have shown that various Cestoda, Acanthocephala, and Eunematoda contain definite poisons (toxins) which, when extracted and employed experimentally, affect particularly the nervous system and the formation of blood. The continued formation and giving off of such substance would explain the apparently excessive results of parasitism in some instances, results which are shown prominently in reflex nervous symptoms. In a certain proportion of cases, pernicious anemia is the result of this toxic effect, and is accompanied by a considerable mortality, reaching seventeen per cent according to one report regarding *Bothriocephalus*. Whether the poison is elaborated by the parasite, or is produced by pathologic processes in the worm or by its death, as well as the ground for the variability in the toxic action of different specimens, are questions as yet undecided. It has been shown, however, that extracts from different species of helminthes vary considerably in toxic power. Vaullegeard has isolated two toxic principles, one of which acts upon nerve centers and the other upon muscles, and many symptoms produced experimentally by the injection of these substances are analogous to those manifested in parasitic disease. According to this chemical theory the troubles caused by parasites are due to the formation of toxic substances more rapidly than their elimination by the host, and their consequent accumulation in the system. A striking instance of the actual effects of parasitism on a large scale is set forth by Stiles (1902) in his description of the general anemic condition and the lowered physical and mental vitality of the families and communities where *Uncinaria americana* is common. These considerations are sufficient to show the greater numbers and more serious effects of human parasites in our own country than has been conceded hitherto.

In view of these facts it would seem hardly necessary to emphasize the importance of the accurate identification of human parasites. They are by no means all of equal etiological rank; some are known to exert deleterious effects upon the human organism, regarding the action of some much doubt exists, and there are others which are believed to be indifferent to man. Some are short-lived, and from knowledge of their life history one may conclude that they are not likely to be met with in large numbers, while in other cases autoinfection renders a considerable increase in numbers probable as is the case with the pin worms, *Oxyuris vermicularis,* or threatens to infest the host with dangerous larval stages as in the pork tapeworm, *Taenia solium.* Furthermore, even of those whose injurious effects are unqestioned, the results on the hosts differ notably, and the line of successful treatment differs equally. It is evidently important then to determine accurately with what species the practitioner has to deal in the individual instance. To-day no one would be satisfied to accept the diagnosis of "fever" and how can the diagnosis of "worms" if made be regarded as more sufficient?

In reaching a precise determination of the forms which may be present, the physician has to deal usually with what is purely a microscopical question. The data which are essential are obtainable only by the use of the microscope, and yet they are very easily secured. They do not involve any complicated technique or the use of high powers and a series of time-consuming cultures is entirely unnecessary. The determination is most readily made from fresh material, and while it should be repeated several times in order to exclude all possibility of deception or accident, it requires only brief time, and the use of comparatively low magnification. A consideration of the factors involved will make the matter clearer.

Evidence of the presence of parasites will ordinarily be obtained by an examination of the blood, sputum, urine or feces. The first three are very frequently examined in the diagnosis of disease, and as a matter of fact they rarely furnish evidence of parasitism. So far as I have been able to learn fecal examinations are rarely made, and yet by them evidence of parasitism would be most largely furnished.

They are neither difficult nor in any conspicuous way disagreeable.

A quantity of fecal mattar may be shaken up with water and by successive decanting and diluting the more solid portions including the parasitic material will be obtained in concentrated form. A small portion of the suspected feces may also be diluted with a few drops of water and after being broken up examined on a slide under the microscope to demonstrate parasitic specimens too small to be detected by the unaided eye. The negative evidence of a single such preparation can not be accepted as final but must be confirmed by a series of observations.

By means of such examination one finds sometimes specimens of the entire adult parasite, recognizable fragments of the same, its embryos or its eggs. It is comparatively rarely that one encounters specimens of the entire parasite, and unless the latter are very abundant such specimens may easily be overlooked if not of such size as to be visible to the naked eye. One is aided, however, in the detection even of small round worms by the definite form with its distinct contour, by the peculiar appearance and sometimes by the movements of living specimens. There is opportunity for confusion with fragments of undigested matter, particularly vegetable tissue which will be discussed later, and the diagnosis should be confirmed by careful microscopical examination of the suspected objects.

The identification of the parasite by some recognizable fragment of the body is regularly made only in the case of the tapeworm which is determined by the passing of segments or proglottids at stools. While the precise determination of the species of tapeworm from the separate proglottids is a matter of more difficulty than ordinarily believed, the cases of confusion resulting therefrom are not such as to introduce any difficulties in the accepted treatment. In passing it may be noted, however, that the determination of tapeworm proglottides as flukes on account of their active independent movements is a frequent error. The examination of such structures even with a hand lens will show the absence of features characteristic of the flukes.

The determination of embryos is not attended with difficulties so far as the different groups are concerned. The embryo of the flukes is oval or elongated, covered with a coating of cilia and so delicate that pressure of the cover glass will crush it completely into granular fragments. These embryos are not common and under normal circumstances do not desert the egg shell; but when brought under conditions of varied osmotic pressure or chemical influence as when feces are diluted by water or urine is changed in acidity on standing, the shell may open and the embryo emerge. This may often be observed on the slide under the microscope.

The embryo of the tapeworm, known as an onchosphere, is precisely characterized by the presence of three pairs of small hooks which lie near one end of the spherical mass. Such embryos are not found free unless some accident has ruptured the membrane, or embryophore, by which each is surrounded.

The nematode embryo is elongate, or vermiform, and possesses a firm outer cuticular layer which is highly refractive and appears under the microscope as a clear structureless boundary. The surface often shows striations on careful examination, and spines or papillae are found near the mouth at the anterior end. The alimentary canal shows at least two distinct regions, an oesophagus or pharynx lined by inverted cuticula and a mid-gut without such lining. In the former various parts may often be made out. A clear area near the center of the worm, consisting of one or a few large cells is the proton of the reproductive system. The size and position of this genital area are of importance in the determination of the species although in many forms it has not been accurately described.

The characteristic features of individual species so far as known are sufficiently fully indicated in the annexed Table II. For the distinction of individual species of *Filaria* by means of the table the data are only partially satisfactory as these forms have been but little studied and are imperfectly known. These worms are probably rare in our fauna unless it be in the southern states and methods of distinguishing them are yet to be worked out.

If any evidence of parasitism is discovered, it is most frequently by the occurrence of eggs. And it is in dealing with these structures that the greatest difficulties in precise determination are experienced. This is in large part due to the inaccurate and insufficient knowledge concerning them. A comparison of the original sources with various manuals shows that serious errors in measurements have crept in and that mention of important and characteristic peculiarities has often been omitted. I have accordingly deemed it wise to include a critical review of these features with illustrations for all species known as human parasites.

The eggs of parasites may be distinguished on the basis of form,

TABLE II.

EMBRYOS OF HUMAN PARASITES.

Species	Form	Size in Microns	Surface	Head	Tail	Sheath	Present In			
							Blood	Sputum	Urine	Feces
Schistosoma hæmatobium	Oval, changeable	60–90 × 40–50	Ciliated	Papilla	o	o			x	
Strongyloides stercoralis	Rhabditiform	300–500 × 16–22	Smooth	Lips	Sharp	o	?			x
Strongyloides stercoralis	Filariform	550 × 15	"	4 Lips	Taper	o				?
Filaria diurna	"	300 × 7.5	"	?	Sharp	Present	x	?	?	?
Filaria nocturna	"	300 × 7.5	"	6 Lips	$\frac{1}{5}$ Taper	"	x	?	?	?
Filaria perstans	"	230 × 4.5	"	Papillated	Truncated	Absent	x	?	?	?
Filaria vulvus	"	250 × 5	"	Rounded	$\frac{1}{5}$ Taper	"	x	?	?	?
Filaria Demarquayi	"	205–210 × 5	"	Retractile spine		"	x	?	?	?
Filaria Ozzardi	"	170–240 × 4–5	"		Sharp	"	x	?	?	?
Trichinella spiralis	Elongate	90–110 × 5–6	"	Blunt	Rounded	o	?			x

Explanation of signs.—x Positive record; ? Possible occurrence, or uncertain record; o Wanting or undescribed.

NOTE.—Small adult Nematoda may easily be distinguished from these embryonic forms by the presence of reproductive and copulatory organs which the latter do not possess.

Ciliated Protozoa should not be confused with larval forms.

size, texture, and other individual peculiarities. Any one of these elements is usually insufficient; but with the exception of a few forms of rare occurrence which are imperfectly known, the group of characters enables one to make a determination. In reaching a decision the observer should, however, keep in mind some general points.

All eggs are not mathematically uniform in size; the range of variation is in most cases small and the average readily obtained by measuring ten or a dozen specimens taken at random. In many cases only the average size, however, has been recorded. The same comparison of a number of specimens will serve to eliminate abnormalities of the individual egg and to give a correct idea of the typical structure.

The occurrence of constant differences in size between the specimens measured and the descriptions given for a species under consideration creates a prejudice at once in favor of the view that the two species are distinct, and some of the supposed wide variations in the eggs of certain species have been found to be due to the confusion of two or more closely related forms under a single specific name.

Errors in the general interpretation of these structures are also not infrequent. The eggs of distomes have more than once been diagnosed as coccidia to which they bear some superficial resemblance in external form. They are, however, usually larger and differ radically in texture and in internal structure as will appear on comparison of the descriptions or figures given in any good text. Thus Braun (1902, p. 75) states positively that the case diagnosed by Thomas (1899) as *Coccidium oviforme* in a brain tumor must certainly be interpreted in some other way and inclines to the view that the questionable bodies were distome eggs. In one case at least the eggs of a known fluke were duly baptized as a new genus and species of coccidia.

The eggs of the Trematoda, or flukes, may be characterized in general as ellipsoidal or ovoidal. The proportion of length to breadth varies so considerably in different species that the form may be that of a spindle in one case, or it may even approximate the sphere. In rare cases the egg is flattened on one side, as in the case of *Dicrocoelium lanceatum* according to Leuckart. One finds as a universal characteristic the presence of a lid which is absent in fact only in a single case. The lid ordinarily conforms to the curvature of the shell, though in rare instances it appears more flattened. Only exceptionally does one find the opposite end of the shell prolonged into a filament of rudimentary character in this group. Where present such filaments constitute valuable criteria in the determination of species. Even in such genera as normally possess them, however, one may find them lacking at times. A knob-like thickening which is present at the lower pole of many fluke eggs may be regarded as the rudiment of a filament.

In appearance the trematode egg varies from light to dark brown in the extreme case reaching almost a mahogany color. When first formed in the body of the parent individual they are uniformly nearly transparent, a feature which is preserved permanently only by *Schistosoma haematobium,* whereas in other species the color begins to appear with the passage of the egg into the uterus, and has reached its final condition at the time when the egg is extruded from the body of the parent. The number of eggs produced by the trematodes which inhabit the human body is large, so that even in the presence of slight infection one finds considerable numbers discharged and their production is maintained over a considerable time. Special data regarding various species are given under the appropriate headings.

Gastrodiscus hominis is a human parasite which has been found only twice, and concerning which the data at hand are not extensive. Leuckart says that the eggs are of oval form, 0.150 mm. long, and 0.072 mm. broad. They are supplied with a firm shell, which at the attenuated anterior end is cut off in the form of a lid. Leuckart notes, moreover (1894, p. 458), that Giles, who was never able to demonstrate the eggs of the parasite in the excrement of the host, propounded the somewhat doubtful hypothesis that the eggs are set free only after the death or expulsion of the parasite.

The common liver fluke, *Fasciola hepatica,* has been studied by many observers. One of the best descriptions is given by Sommer (1880, p. 84). The large, well formed egg in the coils of the uterus (Fig. 12, Pl. IX) measures 0.13 mm. in length by 0.07 mm. in breadth, and up to a length of 0.142 to 0.150. The shell which is at first thin and transparent, is without irregularities save at the pointed pole where a few such occur frequently. The opposite end of the egg is provided with a lid and is regularly rounded or even slightly flattened. When the egg comes to be deposited, it has acquired an intense brown color, which makes the investigation of the contents very difficult. Among them one may distinguish, however, in the earlier stage, a single homogeneous, clear, highly refractive mass of protoplasm, which is the single germ cell. It lies surrounded by a mass of opaque, granular cells, which constitute the yolk mass of the egg.

In *Fasciola magna,* the large American fluke, Stiles (1895, p. 242) who has investigated the species very carefully, says that the eggs (Fig. 11, Pl. IX) can hardly be distinguished from those of *F. hepatica,* although in general they are slightly larger.[*] In proof of this he gives the following table:

F. magna		*F. hepatica*		
Long mm.	Broad mm.	Long mm.	Broad mm.	
		0.105-0.145	0.066-0.090	(Blanchard)
		0.13 -0.14	0.075-0.09	(Leuckart)
0.109-0.168	0.075-0.096	0.13 -0.172	0.072-0.08	(Stiles)

It should be borne in mind that Stiles' measurements of *F. hepatica* were made from American specimens, and it is possible that a change of size may be found in such as have been produced under a different climatic environment. In case of the suspected presence of *F. magna* in man here where it may some time well occur, as does the closely related European species in numerous cases on record in Europe, Stiles' measurements are the most important. It has not yet been shown that the eggs differ in size when produced by parasites in different hosts, although it is well known that the parasites themselves undergo some modification in size and form.

Fasciolopsis Buski (Lank.) which has been hitherto little known has received careful examination within the last year at the hands of Odhner. Regarding the eggs this author says (1902, p. 578): The eggs which are much mixed with aborted specimens are present in large number and measure in length 0.12 to 0.126 mm. by a width of about 0.077 mm. They resemble in all respects the eggs of the large liver fluke (*Fasciola hepatica*). Unfortunately the author does not give any representation of these structures.

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[*] This is not true of the figures given here (Pl. IX, Figs. 11, 12) as the illustration used for *F. magna* represents the *minimum,* rather than as should have been the *average* size for eggs of this species. On the other hand it is also doubtful whether the table quoted from Stiles actually supports his contention as to the relative magnitudes of the ova.

The reports which have been published regarding the egg of *Paragonimus Westermanii* are considerably at variance. The original discoverer of the species Kerbert (1881) gives the measurement of those obtained from the tiger as 0.080 by 0.045 mm. The original account of the species in the United States (Ward, 1894, p. 356) states that the eggs vary from 0.096 by 0.048 mm. to 0.118 by 0.050 mm. with an average size of 0.102 by 0.053 mm.

According to Stiles (1900, p. 603) the average measurements of specimens taken from cysts in the lungs of Kentucky hogs are 0.078 to 0.096 mm. in length by 0.048 to 0.060 mm. in breadth, with an average size of 0.0856 by 0.0532 mm. The most recent investigation of the species by Katsurada (1900a, p. 508) gives the following data for eggs taken from the sputum of the human host: Minimum 0.0875 by 0.0575, maximum 0.1025 by 0.0525 mm. with an average size of 0.0935 in length and 0.057 in width. He says that the fully formed egg (Fig. 2, Pl. VIII) has an oval, clear yellowish brown, relatively thin shell, broad at one end, and somewhat tapering at the other; the tapering end has the thicker shell, and the other end shows a somewhat flattened small lid. The contents of the egg within the shell are covered by a thin membrane and in the space between the granular yolk masses, a clear viscous fluid is found.

The measurements as stated by different authors have been put together in an outline sketch which represents the differences in graphic manner (Fig. 1, Pl. VIII). It will be noted that there are only two wide variations from the general size as given by the majority of authorities. Regarding the eggs which are unusually large, according to the measurements of Baelz (1880), it may be said that the same author later (1883) gives lesser measurements for specimens obtained like the first from the sputum of man, so that one may suspect an error in the earlier record. On the other hand, the measurements given by Yamagiwa (1890, p. 455) were taken from sections of the brain and lungs of man. Their subnormal size may be due to an error in measurement, or to a determination of the size from fragmented specimens, or to eggs situated obliquely in the section and consequently reduced in length. It is difficult to believe that all records can be correct as they stand, unless some other species is concerned.

The eggs of *Opisthorchis felineus* have been described by Braun (1902, p. 158) as oval, with sharply marked operculum at the pointed pole and containing an embryo in which cleavage is already well advanced. They measure 0.030 by 0.011 mm. (Fig. 8).

Opisthorchis sinensis has been investigated by a number of observers. Ijima (1887, p. 11) says: The eggs are unusually small, measuring 0.028 to 0.03 mm. in length and 0.016 to 0.017 mm. in breadth. In the anterior portion of the uterus, where the egg shells have assumed a dark brown or dark olive color, embryos are already formed (Fig. 6, Pl. VIII). In the interior three distinct remnants of yolk matter are seen in addition to scattered yolk granules. Embryos can be forced out of the shell by a sharp tap on the cover glass. Such have an elongated shape and measure 0.025 mm. in length. The body tapers slightly towards the posterior end, and there is an indication of head papillae. The posterior portion contains small clear cells, probably terminal and there are no eye-spots present.

Of the same species Katsurada says (1900, p. 481) that the previously published accounts agree well with facts, but cites as an especially accurate investigation that of Dr. Osafune, who measured 500 eggs from feces and found that the majority were from 0.027 to 0.030 mm. long, and 0.015 to 0.0175 mm. broad, exceptionally specimens were found with a length of 0.035 mm. and a breadth of 0.019 mm., and on the other hand such as were only 0.02 long and 0.0157 broad, or 0.0225 long and 0.015 broad were also present (Fig. 7, Pl. VIII).

The Egyptian Fluke, *Heterophyes heterophyes,* has been carefully studied by Looss (1894, p. 32) who speaks thus about the egg: The fully formed eggs which immediately after their formation, possess a completely transparent hyaline shell, are comparatively regularly oval, slightly more pointed at the lid pole than at the opposite. They possess a length of 0.03 mm. by a greatest breadth of 0.017 mm.; their shell is 0.001 mm. thick and has thus a relatively considerable strength. During the passage of the eggs through the uterus, the embryo is formed, so that the egg which has arrived at the end of this organ possesses in its interior a developed embryo (Fig. 9, Pl. VIII). The latter possesses, so far as one can determine through the egg shell, an elongated cylindrical form, and carries at the anterior end a weakly marked projection. The surface of the body is covered in its entire extent with cilia which are most evident in the anterior region. In the posterior end large transparent spheres, 0.008 mm. in diameter, are the germ cells of the embryo.

In *Dicrocoelium lanceatum* (Fig. 3, Pl. VIII) the eggs are, according to Leuckart (1889, p. 376), ovoid in form, with the lid end notably flattened, while the same is true for one side of the shell (Fig. 4). In size, as well as in detail, there are many differences in form among the fully developed eggs. The length varies from 0.04 to 0.045 mm., and the breadth from 0.02 to 0.03 mm. When first formed, the egg is, as in many other cases, almost transparent, but during the passage of the uterus it becomes very dark brown. At the same time the embryonic development is being completed, so that the eggs when deposited contain an embryo which is already fully developed. Leuckart gives the length of this embryo according to his own measurements as 0.026 to 0.030 mm. and the breadth as 0.016. The embryo occupies exactly the center of the egg so that an even space intervenes between it and the shell everywhere. There is also a mass of granular matter, usually at one end, surrounding the head end of the embryo like a cap, and more or less completely concealing it.

Three other trematodes have been reported from the human host, namely *Opisthorchis noverca, Fasciolopsis Rathouisi* and *Fasciola angusta.* There is on record but a single case of each, and the eggs are not sufficiently well known to make them available for determination. Moreover in the case of such an exceptional species more than the evidence furnished by the egg would be necessary in order to establish its occurrence in the human host.

The eggs and embryos of *Schistosoma haematobium* have been carefully studied by Looss, whose observations are reported by Leuckart (1894, p. 521). According to this investigator, whose studies were made upon eggs discharged with urine, such either contain an embryo ready to hatch out, or are dead and calcified. The normal eggs are somewhat variable in form, though in general spindle shaped with median enlargement (Fig. 10, Pl. IX). At the posterior pole is a characteristic filament, often very inconspicuous, though universally found in the eggs taken from urine. Within the shell is a yolk membrane, with granules, surrounding the embryo. According to this author the eggs will not hatch, so long as retained in the urine, but rather perish if permanently kept in that fluid. The addition of water even, in small amounts, brings about the opening of the egg. The enclosed embryo is exceedingly variable in form, with an insignificant cephalic papilla, a coating of cilia and the usual enclosed cell masses of the larval distome.

The eggs of the Cestoda, or tapeworms, are usually spherical, oval or elliptical, although occasional species are characterized by a polyhedral form. In general they manifest great constancy, although the outer membranes may be modified by shrinkage or the aspect of the egg may be changed by their absence, so as to produce decidedly variable effects. Frequently one finds filaments of various kinds which are projections of the shell, and are present either at one or both poles of the egg. Among human tapeworms they have a very rudimentary character and are demonstrable as a rule only in younger and smaller eggs. In color the tapeworm eggs are at first almost transparent, but later yellowish to brownish in tone.

Among the tapeworms one finds both such eggs as are possessed of a small lid, often difficult to demonstrate, and also those which are beyond doubt without such a structure. Among the higher forms, the eggs are small with delicate, colorless and often deciduous shell. By the formation of a number of embryonic membranes the embryo proper which is usually developed at the time when the egg is set free, is separated from the shell by a noticeable distance. The embryo itself is small, usually spherical, and regularly armed with six hooks arranged in three pairs near one pole. This six-hooked oncosphere, as it is called, is borne in an inner membrane of considerable thickness, and often prominent in appearance by virtue of its structure, and to this the name of embryophore has been given. It is of all the membranes the most constant in presence and appearance. Special characters of individual species are noted as follows:

For *Dibothriocephalus latus* (Figs. 13, 14, Pl. IX) the description given by Schauinsland (1886, p. 529) is as follows: The eggs possess a thick brown shell, and a small lid, which becomes especially distinct at the close of development. They contain a large amount of yolk substance, and do not increase in size. As in all Bothriocephalids the development is carried out in the water and not in the maternal body, so that the inconspicuous egg cell is only rarely to be found in the mass of yolk cells which usually completely conceal it.

In the large Japanese tapeworm, *Diplogonoporus grandis,* the egg taken from the uterus possesses a deep brown shell (Fig. 15, Pl. IX) according to the account of Ijima and Kurimoto (1894). The shell is rather thick, the general form is oval, 0.063 mm. long and 0.048 to 0.050 mm. broad. The diameter of the operculum is 0.02 mm. and the contents of the shell consist of oil globules and a mass of cleavage cells.

In *Hymenolepis diminuta,* according to Blanchard (1891, p. 46), the egg is rounded or oval (Figs. 16, 17, Pl. IX). It measures from 0.060 to 0.070 or even 0.086 in diameter. The external membrane is yellowish, delicate, and manifests indistinct striation, the median membrane is doubled, the internal membrane or embryophore has ordinarily two polar knobs, to which are attached no filaments, however. The onchosphere is elliptical and measures 0.036 by 0.028 mm. Its hooks are 0.011 mm. long.

Of *Hymenolepis nana* (v. Siebold) von Linstow (1896, p. 575) says that according to his observations the eggs are in the rule spherical, more rarely also oval ones are present. They show two membranes, of which the external is delicate and irregular. The inner is regular and sharply doubly contoured. This shows at two opposed points an indistinct attachment from which a filiform appendage proceeds that is three to four times as long as the egg. Both these threads lie rolled up between the two egg membranes and may simulate a median third membrane (Fig. 18, Pl. X). The external membrane measures 0.039 mm., the internal 0.028 mm. in diameter. The hooks of the onchosphere measure 0.0092 mm.; in an especially elongated egg the external membrane was 0.043 mm. long and 0.031 mm. broad, the inner 0.029 and 0.024 mm.

The eggs of *Taenia saginata* have been described by a number of authors. The fullest comparison of the data thus obtained are given by Leuckart (1886) whose work in the main is followed here. These eggs are usually still covered by a thin yolk membrane, having a diameter of about 0.07 mm., which is frequently drawn out at two opposite points into long delicate projections, of which, however, only a single one may be evident (Figs. 19, 20, Pl. X). In eggs just formed in the uterus, which measures on the average 0.02 mm., the form is commonly oval, and the projections constant at the poles, with a length about equal to the diameter to the egg. The embryophore is characterized by the considerable thickness or length of the rods which compose it, and measures in diameter approximately 0.03 mm., in which connection one should notice that the form of the same is commonly more oval than spherical. The embryo itself measures 0.02 mm. in diameter.

In *Taenia solium,* Leuckart (1886, p. 667) says that the embryophore, like that of *Taenia saginata* is thick and firm, brown in color, and covered with numerous rods, but more nearly spherical. In diameter these eggs measure 0.03 mm., while the onchosphere measures not more than 0.02 mm. The embryophore is often the only membrane present (Figs. 21, 22, Pl. X).

In *Taenia confusa* Ward, as described by Guyer (1898, p. 19), the eggs are oval in form in the ripe proglottis. They posses on the exterior a thin, transparent membrane, and within it a layer of little rods, side by side. Next within this is a thin space, or layer, the exact nature of which could not be determined. The elongated inner portion is of about the same outline, as the external covering of the egg, and is of different appearance in different specimens. In some there is a dark cap-like structure at one end; in others at both ends, and in still others along the side and one or both ends, while the entire center is usually dark. In no case could the pyriform apparatus, or tail-like processes, mentioned by Leuckart for the eggs of *Taenia saginata,* be determined. It is not unreasonable to suppose however, that since they are very delicate, they may have been present, but were destroyed through the poor preservation of the material. These eggs measure in general 0.039 mm. long and 0.030 broad. They are of whitish or yellowish color (Fig. 24, Pl. X).

In *Taenia africana* a new species recently described for the human host in Africa, the eggs are described by von Linstow (1900, p. 491) as very thick shelled. The shell is formed of a radially striated membrane which appears on the exterior finely granulated. These eggs measure 0.0312 to 0.0338 mm. in diameter. There are also present some oval specimens which are 0.0390 long and 0.0338 mm. broad. The six hooks of the onchosphere are very distinct and measure 0.0078 mm. in length (Fig. 23, Pl. X).

Two other species of cestodes, *Dibothriocephalus cordatus* and *Dipylidium caninum* also have been reported from the human host.

In the former case the eggs are not well known, and in the latter case they are cemented together in masses, which makes an individual description of little value. One of the latter species, however, is represented in Plate X (Fig. 25) after Diamare (1893). Much the same holds true of *Davainea madagascariensis,* while *Hymenolepis lanceolata* is apparently an occasional parasite merely and other forms definitely reported from man are in the larval condition in that host. Moreover, in the determination of cestodes in general the eggs are of secondary importance, since one will secure additional evidence in the form of the occurrence in the feces of single proglottids or groups of such which have been set free from the parent chain.

Among the round worms, or Nematoda, the greatest differences may be found in the character of the eggs. In a large number of cases, especially in the group of the Filariae, the forms are viviparous, and no eggs are known. Among such, however, as produce eggs, one finds wide variety in the character of this structure. In the one case it is thin shelled, and reduced it may be to a delicate membrane, containing an already well developed embryo. At the other extreme the shell is thick and impermeable, or surrounded by a mammellated albumen coat, which gives the structure a very characteristic appearance. In the case of the heavy shelled egg, development has usually not proceeded far, and the formation of the embryo takes place only at some time after the expulsion of the egg. The thick shell is here evidently a means for protection and nourishment of the embryo, a feature which is unnecessary in the case of those eggs deposited when the embryo is almost ready to carry on an independent existence. All differences between the two extremes may be found in different species. In addition to the Filariae which have no egg, and the small free living Rhabdites which are accidental parasites, several species of nematodes are so infrequent that we know little with regard to conditions respecting the egg. Such species are *Gnathostoma siamense, Strongylus apri, Physaloptera caucasica,* and *Ascaris maritima.* The ovoviviparous *Trichinella spiralis* may also be excepted from the list of those, the eggs of which are under discussion. In one case at least nematode eggs have been taken for coccidia (Cf. Braun, 1902, p. 68, footnote).

The eggs of *Strongyloides stercoralis* (Fig. 44, Pl. XI) have been his description they are of elliptical shape, with a thin, clear yellowish shell, and granular contents, which were distinctly in cleavage. They measured about 0.0675 by 0.0375 mm. He calls attention to the fact that these measurements exceed those of the eggs of the parthenogenetic mother worm given by various authors, and cites Parona and Grassi (1879) who give the measurements as 0.06 by 0.04, while Braun (1902) and Raillet (1895) states them as 0.050 to 0.058 by 0.030 to 0.034 mm. Although authors are unanimous in stating that eggs are present at stools only with the greatest rarity, he gives good reasons for accepting the correctness of his observation, and calls attention to the agreement with the measurements of several other authors. At the same time he shows that the eggs described could not have belonged to the sexual intermediate generation.

In the whipworm, *Trichuris trichiura,* the eggs (Figs. 37, 38, Pl. XI) are easily recognized. They are ellipsoidal with a brown heavy shell, which is apparently perforated at both poles, while the orifices are closed by transparent plugs. Such eggs occur in the feces before cleavage has taken place and they measure 0.05 to 0.054 mm. in length by 0.023 in breadth.

In *Dioctophyme renale,* a rare human parasite, the egg has been well delineated by Balbiani whose figures (Figs. 26, 27, Pl. X) are copied here after Railliet (1895). The original description is not accessible.

In *Strongylus subtilis* Looss the ripe eggs (Fig. 43, Pl. XI) are described by that author (Looss, 1895, p. 169) as of oval form with a length of 0.063 mm. and a breadth of 0.041 mm. The shell is very thin and the content strongly granular, so that the nucleus cannot be recognized. At the same time Looss believes that cleavage does not take place in the interior of the female organs.

Investigating what is probably the same species in Japan, a year later Ijima writes (1896, p. 160) that he has found a larger number of eggs in the uterus, and that those which lay nearer the exit were in the process of cleavage. He also discovers a few free eggs exactly comparable to the uterine egg mentioned previously. These measured 0.08 mm. in length and 0.035 to 0.04 mm. in breadth, while the granular yolk was split into numerous cleavage spheres, 0.005 to 0.01 mm. in diameter, forming a solid morula-like mass. Yet at both ends of the egg there was a narrow unoccupied space between this and the thin hyalin shell. Possibly this space explains the greater length of the egg as given by Ijima in comparison with the statements of Looss cited above.

In *Uncinaria duodenalis,* the eggs (Fig. 28, Pl. X) have been carefully investigated by Schulthess (1882, p. 215), who gives the following description: They reach maturity in the uterus, and are possessed of a thin, doubly contoured shell, oval in form, although one side is often flattened somewhat. He cites the following table regarding the size of the egg according to different observers:

	Length, mm.	Breadth, mm.
Leuckart	0.044–0.050	0.023–0.027
Perroncito	0.052	0.032
Hindenlang	0.0626	0.0319
Roth	0.064–0.072	0.032–0.024
Bugnion	0.059–0.060	0.040–0.041

According to Schulthess' own measurement the eggs vary from 0.0602 long by 0.0382 broad to 0.0674 long by 0.0359 broad, or 0.0602 long by 0.0449 broad. This author ventures also the remark that his investigations do not support the supposed considerable variations in size, and that his own figures give the extreme values for numerous measurements.

In the new American hook worm, *Uncinaria americana* Stiles, the description given by that author (Stiles, 1902, p. 193) records the size of the ova as 0.064 to 0.072 mm. long by 0.036 to 0.040 mm. broad, ellipsoidal in outline, in some cases partially segmented in the uterus, while in other cases they contain a fully developed embryo when deposited. The egg possesses a very thin shell without characteristic features (Figs. 29–32, Pl. X).

The eggs of the common round worm, *Ascaris lumbricoides,* are usually easily recognized by their characteristic mammelation. They present, however, certain variations which render confusion possible in some cases, as in that recently described by Miura and Nishiuchi (1902, p. 637), from whose account the following data are excerpted: The normal fertilized eggs are round to elliptical, with threefold thick shell, and mammellated albumen covering of yellowish tone. The content of these fertilized eggs (Figs. 33, 34, Pl. XI) is finely granular, and round in form, so that at both poles between the content and the elongated shell one may distinguish a crescentic space filled with a clear fluid. In the center of the spherical mass the nucleus may frequently be distinguished as a clear space.

On the other hand, the unfertilized eggs (Fig. 35, Pl. XI) are elliptical or oval with irregular contour and occasionally with lateral curvature of the shell. The form, however, manifests numerous variations, which are apparently due to the low resisting power of the shell, and to the irregular distribution of the albuminoid covering. The shell proper is doubly contoured, relatively thin, and with a less distinct internal boundary. The content of the shell consists of large, highly refractive bodies, which fill the entire space without evidence of the crescentic clear area near the poles, as in the fertilized egg. Such eggs measure on the average of numerous measurements 0.081 in length by 0.045 mm. in breadth, varying from 0.030 to 0.060 in transverse diameter, and from 0.063 to 0.098 in length. The fertilized eggs measure according to the same author 0.049 mm. in transverse diameter, and 0.065 mm. in longitudinal diameter, which is closely in accord with figures given except by French authors, who cite the length from 0.075 to 0.087 and the breadth as 0.058 mm.

The egg of the related species *Ascaris canis* from the cat and dog, also found occasionally in man, is represented (Fig. 36, Pl. XI) after Braun (1902).

The eggs of *Oxyuris vermicularis* are rarely met with in the feces. They are, however, of oval form, with very thin shell, measuring 0.05 by 0.016 to 0.02 mm. When deposited they contain an already well developed embryo (Figs. 39–42, Pl. XI).

Some of the Acanthocephala have rarely been reported as human parasites. Their eggs when fully formed possess three membranes, and have carried their development to the formation of an embryo in the body cavity of the female worm. In the case of *Gigantorhynchus gigas* the eggs found in feces are with the three membranes, of which the middle one is the thickest. The external measurements of the entire mass vary 0.08 to 0.1 in length (Fig. 45, Pl. XI).

It is necessary now to call attention to possible results of the examination in the way of non-agreement of the forms discovered with the data at present known regarding human parasites. The non-agreement may of course point to the discovery of a form new to the world, and most frequently has resulted in the description of the form under these conditions as a new species which has been duly baptized. Unfortunately there are two other possibilities which are more frequently met with than the one just cited, and a disregard of them has led to great confusion. It may be in the first place that the species is new to the human host, but is one which is known from some other host. It consequently should not receive a new name, but should be discussed merely in the light of its occurrence under these conditions heretofore unknown.

Such a species may be normal to the human host as well as to that from which it was previously known, but a considerable range of cases must be brought forward in order to demonstrate this fact. In the case of a normal human parasite this will not be difficult after attention has once been drawn to its occurrence in a given region, and a failure to find further evidence of the occurrence of a new human parasite increases the probability that the form discoverd falls into some other category always provided that the patient has not been in some other locality, in which of course the parasite may well have been acquired. Such cases throw an interesting side light on the dispersal of human parasites. The determination of a single case in a host of local habit inclines to the belief that it represents an instance of occasional or accidental parasitism; and this brings us to consider the possible types of parasitic existence.

One may recognize among human parasites those which occur in their normal host but in an unusual location, like the brain cysticerci or a liver fluke in a subcutaneous cyst and these may be spoken of as erratic; there are also many of the species listed which can not be regarded in any way as characteristic of the human host. Such are the occasional parasites which are species of true parasitic habit and can attain normal development in the human host but ordinarily do not find conditions favorable for their introduction. As an instance of such species may be mentioned *Fasciola hepatica,* the common liver fluke of the sheep which in many regions of the world is extraordinarily abundant. That it can thrive in the human system is demonstrated by the score or more cases of its occurrence there definitely recorded, but its infrequence is equal evidence of a general immunity on the part of man, lacking in these particular cases, or, of special features in its life history which make the infection of the human host difficult. That the latter is the probable explanation may be inferred from the fact that the cercaria larva, liberated from the intermediate host, encysts on plants and hence could only reach the human alimentary canal under unusual circumstances. Similar examples may be taken from other groups of parasitic forms such as the rare occurence in man of *Strongylus apri*, one of the commonest parasites of the pig in Europe, or of *Dipylidium caninum*, the cosmopolitan tapeworm of both dog and cat which has been reported only rarely from man.

Such occasional parasites often occur under abnormal conditions; thus, a fish nematoda, *Ascaris clavata*, was discovered once in the hollow tooth of a man. Here the position was probably accidental, but in other cases it is the result of the action of the parasite itself. So the "red spiders," or "jigger" mites of the central states, bury themselves in the skin of man although such a position is so clearly abnormal that in fact it destroys the chance of further development and costs the parasite its life. A small leech, *Limnotis nilotica*, common in the circum-mediterranean area, is often drawn into the throat of men and other animals drinking at wayside pools. It usually retains its position, causing serious difficulty, until removed by operative interference; hence it has become an occasional parasite of man rather than as most leeches, a temporary parasite; or one may regard it as falling in the next following group of accidental parasites. This example shows most clearly the narrow and somewhat artificial limits which separate these groups of parasites from one another. Of the mites also which have been reported a few times as obtained living from stomach, bladder and rectum, it is difficult to say whether they are occasional or accidental parasites of man.

There are also rarely forms which commonly occur free living, but which by chance are introduced into some organ in which conditions are such that they can thrive. They became thus accidental parasites, a group difficult practically to distinguish from the last, the occasional parasites, and yet presenting somewhat different biological conditions. The recent discovery by Stiles and Frankland, as well as others, of the vinegar eel, *Anguillula aceti*, as an apparently successful colonizer of the bladder in a female patient illustrates the type under consideration. There is little doubt that this parasite was introduced through the use of vinegar in vaginal douches and effected a successful colonization, possibly by virtue of the trace of albumen present in the urine which furnished it with nourishment. Equally striking is the case of Scheiber who discovered *Pelodera* *pellio* in the urine of a female patient in Hungary. This typical slime inhabiting nematode gained entrance no doubt through the application of mud poultices which are commonly employed by peasants in that region. It should be noticed that such accidental parasites are necessarily confined to those groups of animals which have free living forms. Such are Protozoa, Nematoda, and perhaps Insecta in the larval conditions, while Cestoda and Trematoda, which live only as parasitic forms in some host, would become rather occasional parasites of man should they stray into the human system in some chance manner and find favorable conditions for existence.

Quite distinct from the types just considered are pseudo-parasites which rank high in clinical importance. Among them one may recognize several very distinct classes. First, those which are actually free living animals, introduced by accident, usually in food or drink, into the human alimentary canal, and exciting there abnormal conditions which induce their more or less immediate and forcible expulsion. Thus Botkin found in the vomit of a Russian numbers of a small nematode which he wrongly believed to be a human parasite. In fact it lives normally in the onion and its introduction into the stomach with this food excited the untoward symptoms noted. Similarly, Blanchard records a case in which coleopterous larvae were found in the vomit of a child.

That such may be the result of introducing a true parasite from some other host is indicated by several cases like that of *Ascaris maritima* which Leuckart described from a single specimen vomited by a child in Greenland and which this author noted was very similar to *A. transfuga* of the brown bear. In all probability it was ingested with the viscera of some animal (seal?), though it may have been a species which had strayed into this unusual host only to make its appearance under the circumstances noted.

Of similar import are the cases of *Gordius,* the hair snake, which have been reported from man. In the adult condition this is normally a free living species but about a dozen specimens have been taken from man after a supposed sojourn of from a few hours to fourteen days. Some of these have been vomited and others passed per anum. This form has often been passed off upon the physician as a true parasite, and in one celebrated case at least as the Guinea worm.

In the same way one may find the explanation for other isolated cases of parasitism, even when the parasite is reported to have been passed from the alimentary canal. Thus Cobbold reported that larvae of *Blaps mortisaga,* the English churchyard beetle, were found in fecal discharges and many authors have recorded the presence of dipterous larvae in the alimentary canal.

The majority of such observers have inclined to regard the larvae as temporary endoparasites and to consider that they have accommodated themselves to the conditions present in the human host. The cases seem to show that these larvae live for some time in the canal and they often appear to evoke serious or even fatal disturbances; and yet the conclusions are open to grave doubt for Calandruccio experimented extensively on two families to which many of the supposed accidental parasites belong and found that the ingested larvae were regularly and promptly evacuated dead or dying and in no case secured a footing in the canal.

Among the Myriopods about forty recorded cases of pseudoparasitism have been brought together and discussed by Blanchard. In the large majority the animal was taken from the nasal fossae, though in a smaller number it was actually obtained living from the alimentary canal where it undoubtedly can exist for a brief time in spite of the untoward environment. The ingestion of such forms is purely accidental, the symptoms those of helminthiasis in general and their stay at most very limited. They never show any evidence of adaptation to the new environment.

In some such accidental fashion other forms are sometimes introduced into various organs not connected with the alimentary system. Thus Trouessart reported the occurrence of a species of detricolous Sarcoptids in the human testicle where the mites formed an old colony in a painless cystic tumor.

In contrast with the living animals of the types noted, the second class of pseudoparasites includes a large number of other structures which have been described as parasites. These may be considered conveniently in a few groups, the first of which includes bodies which are parts of the so-called host animal itself. Thus fragments of the arteria hyaloidea have been described as eye worms (*Filaria lentis, F. oculi-humani,* etc.), the organisms of whooping cough are nothing more nor less than ciliated tracheal cells torn from the wall and found in the sputum in distorted form, while groups of small axillary and inguinal glands, hydatid moles, and Pacchionian bodies from the arachnoid have been frequently put on record as hydatid cysts.

Parts of substances used as food, both of plant and of animal origin, which have not been destroyed by the action of digestive juices are also among the pseudoparasites of man. The radulae of the common limpet have been reported several times from stools; the seeds of the mulberry were duly baptized as parasitic worms; and plant vessels and other similar undigested structures of peculiar appearance appear periodically as new helminthes. That a differentiation of such structures is not simple appears from the account given by Stiles of the partially digested banana fibers which closely simulate minute tapeworms. Wynn has found a good facsimile of tapeworms in blackened but undigested strips of cold slaw. Some years ago Leuckart entrapped a group of research students in helminthology with the pulp vesicles of an orange which were found in a fecal examination.

In all of the cases considered above it should be kept in mind that the animals or these other structures actually came from within the human body. It is necessary that the investigators have absolute evidence on this point, for there is another class of objects of which this cannot be said, and these call for brief mention here.

In determining the nature of unusual forms reported from man it should always be kept in mind that in the absence of positive personal evidence, suspicion in cases of neurasthenia at least favors the deceitful introduction of doubtful bodies. In many cases on record such things as earthworms, chicken entrails, etc., have been forcibly introduced into the rectum or vagina and have been subsequently reported by the attending physician as undoubted human entozoa of a remarkable character! Here as elsewhere the appearance of unusual structures should at once arouse the suspicion of the physician and call forth a most searching examination of the case in all its factors that any deceit be disclosed or that in event of the discovery of some rare parasite all conditions connected with its appearance be put on record for future use. Furthermore, it is important to preserve the fullest data in regard to any substances associated with the supposed parasite as well as concerning the food of the patient, whether usual or unusual, since in this way some hint as to the introduction of the questionable body may be found.

Finally, it is important to direct attention to the wisdom of preserving all material, whether new and doubtful or not, in considerable quantities, and both of the eggs and embryos as well as the adults, or as many thereof as can be obtained. In case of doubt regarding the identification of species, or possible question as to the source, it is important that the material, or some portion of it, should be referred to some expert helminthologist for examination and verification of the result attained. It is always a pleasure to have the opportunity of examining such material, and to assist one's colleagues in any way in connection with such studies. In most cases, in fact, and especially such as deal with the occurrence of rare forms, or such as are new, it is desirable that such corroborative evidence should be secured before publication, for in this way is often prevented the confusion which arises from incorrect descriptions or from the publication of new names which are merely synonymous with those already known to science. As a matter of fact, the practitioner can hardly hope to be acquainted with the entire range of parasitic species, and if to the accurate observations which he records regarding the clinical side of the question can be appended the notes of some helminthologist who is in position to give an expert opinion regarding the other side, the results are far more valuable to the world from their rounded scientific character and permanent value, than could be attained by the publication of either group of factors separately.

The large number of parasites in other animals which some unusual combination of circumstances may bring into the human system makes it imperative also that any supposedly new species be submitted to the judgment of a specialist before it is described as such. Only in this way can the discoverer avoid adding to the long list of synonyms which already burden the literature of this subject and render it so difficult for the investigator not a specialist in this particular line to find his way aright.

Reference has also been made to the grosser errors in determining the character of objects discovered in microscopical examinations. Some of these have been detected by virtue of evidence drawn from attendant circumstances; it may be equally positively asserted that many such have not been recognized though suspected and others still remain entirely unsuspected. To such errors in interpretation as well as to such as are due to faulty observation the scientific world owes a long list of anomalous, inexplicable and often unthinkable occurrences listed in the chronicles of helminthology as in other fields of science. Progress depends upon the elimination of these errors and the substitution of more accurate methods.

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PLATE VIII

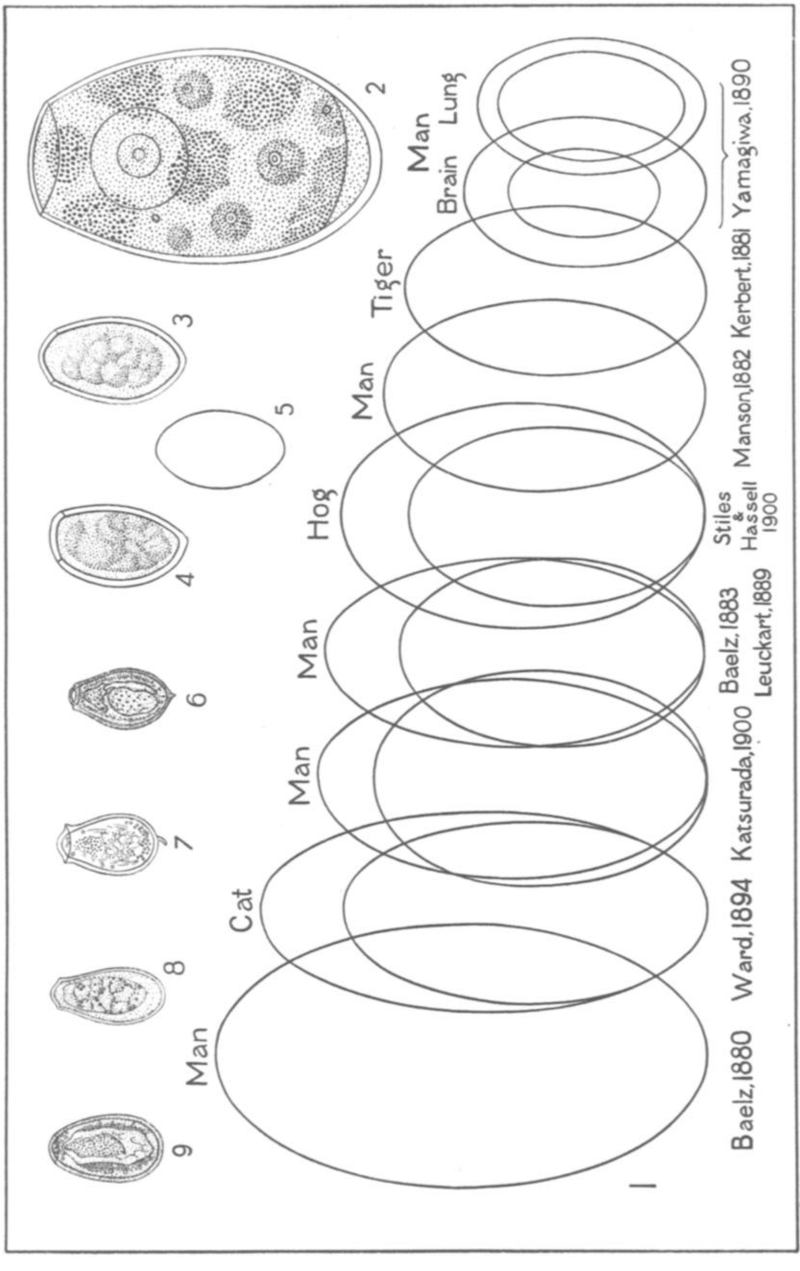
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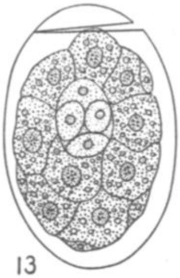
PLATE IX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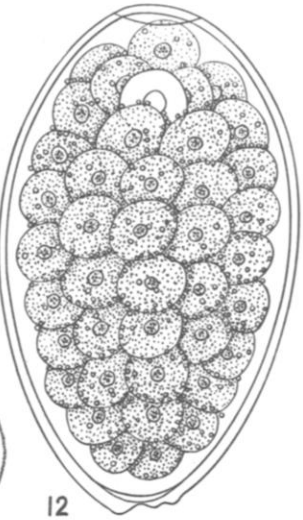
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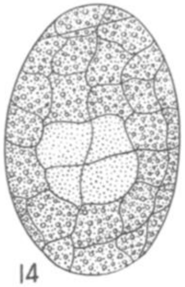
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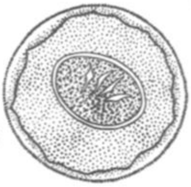
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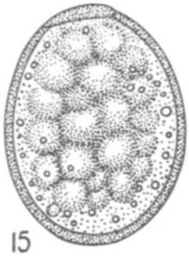
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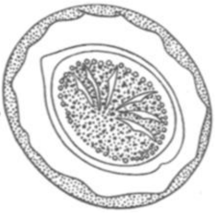
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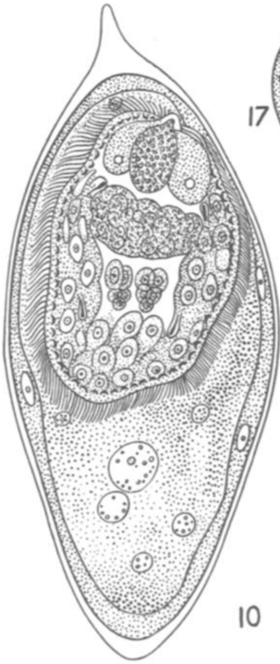
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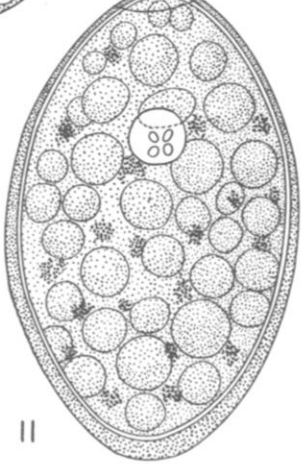
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EXPLANATION OF PLATES

All of the figures have been reduced to the same scale in copying and the reproduction has brought all to the magnification of five hundred diameters. They usually represent the average size of ova in the given species.

Plate VIII

Fig. 1. Composite outline of the egg of *Paragonimus Westermanii* according to various authorities. The host is indicated above each outline; the author and date below. The outer oval gives the maximum, the inner the minimum of each observation.

Fig. 2. Egg of *Paragonimus Westermanii* from sputum of man. After Katsurada, 1900*a*, p. 507.

Fig. 3. Egg of *Dicrocoelium lanceatum* in surface view. After Braun, 1902, p. 168.

Fig. 4. The same in lateral aspect.

Fig. 5. Outline of egg of *Opisthorchis noverca.*

Fig. 6. Egg of *Opisthorchis sinensis.* After Ijima, 1887, pl. 7, fig. 3.

Fig. 7. Egg of *Opisthorchis sinensis.* After Katsurada, 1900, pl. 13, fig. 8.

Fig. 8. Egg of *Opisthorchis felineus.* After Braum, 1902, p. 158.

Fig. 9. Egg of *Heterophyes heterophyes.* After Looss, 1896, pl. V., fig. 39.

Plate IX

Fig. 10. Egg of *Schistosoma haematobium* from the urine of man. After Looss, 1896, pl. XI., fig. 112.

Fig. 11. Egg of *Fasciola magna.* After Stiles, 1894, p. 227, fig. 4. This figure is drawn to the minimum, not to the average size of ova in this species.

Fig. 12. Egg of *Fasciola hepatica.* After Sommer, 1880, pl. VI., fig. 1*c*.

Fig. 13. Egg of *Dibothriocephalus latus* with operculum opening. After Schauinsland, 1886, pl. VII., fig. 31.

Fig. 14. The same, earlier stage. After Schauinsland, 1886, pl. VII., fig. 29.

Fig. 15. Egg of *Diplogonoporus grandis* taken from the uterus. After Ijima and Kurimoto, 1894, pl. XVIII., fig. 9.

Fig. 16. Egg of *Hymenolepis diminuta.* After Blanchard, 1891, p. 45.

Fig. 17. The same, elongated form.

Plate X

Fig. 18. Egg of *Hymenolepis nana.* After von Linstow, 1896, p. 580, fig. IV.

Fig. 19. Mature egg of *Taenia saginata.* After Leuckart, 1886, p. 568.

Fig. 20. The same without external membrane. From human feces. After Leuckart, 1886, p. 186.

Fig. 21. Egg of *Taenia solium.* After Leuckart, 1886, p. 667.

Fig. 22. The same without external membrane. From human feces. After Leuckart, 1886, p. 186.

Fig. 23. Egg of *Taenia africana.* After von Linstow, 1900, p. 489.

Fig. 24. Egg of *Taenia confusa.* After Guyer, 1898, pl. XXVIII., fig. 11.

Fig. 25. Egg of *Dipylidium caninum.* After Diamare, 1893, pl. I., fig. 18.

Fig. 26. Egg of *Dioctophyme renale* in surface view. After Balbiani from Railliet, 1893, p. 421.

Fig. 27. The same in optical section.

Fig. 28. Egg of *Uncinaria duodenalis.* After Parona and Grassi, 1878, pl. II., fig. 6.

Fig. 29. Egg of *Uncinaria americana* from human feces. After Stiles, 1902, p. 193.

Figs. 30–32. Same with cleavage begun.

Plate XI

Fig. 33. Egg of *Ascaris lumbricoides* from human feces. Seen in surface aspect. After Stiles, 1902, p. 202.

Fig. 34. Same in optical section.

Fig. 35. Unfertilized egg of *Ascaris lumbricoides* from human feces. After Miura and Nishiuchi, 1902, p. 638.

Fig. 36. Egg of *Ascaris canis.* After Braun, 1902, p. 303.

Fig. 37. Egg of *Trichuris trichiura* from uterus of female worm. After Leuckart from Stiles, 1902, p. 202.

Fig. 38. Same in stage from human feces.

Figs. 39–41. Eggs of *Oxyuris vermicularis* taken from uterus of female worm. After Leuckart from Stiles, 1902, p. 202.

Fig. 42. Same in stage found in human feces.

Fig. 43. Outline of egg of *Strongylus subtilis.* The larger oval and the cleavage cells from eggs free in stomach contents, after Ijima, 1896, p. 160; the smaller oval from eggs before deposition after Looss, 1895, p. 169.

Fig. 44. Egg of *Strongyloides stercoralis* from human feces. After Thayer, 1901, pl. IX., fig. A.

Fig. 45. Egg of *Gigantorhynchus gigas.* After Leuckart from Braun, 1902, p. 309.

PLATE X

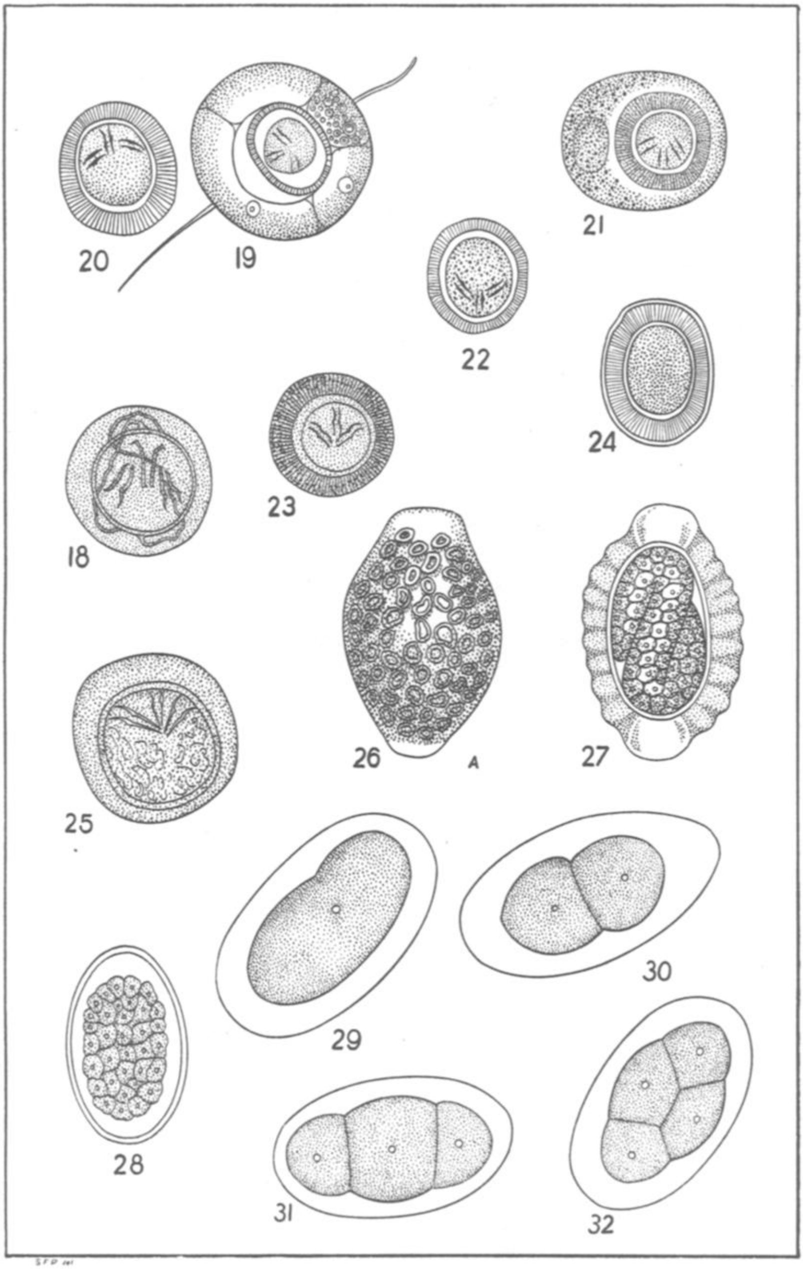

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PLATE XI